

Pond Apple Slough Preliminary Assessment and Rehydration Test

Technical Publication WS-10

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EXECUTIVE SUMMARY

Pond Apple Slough is a 112-acre urban wetland in eastern Broward County. The unique characteristics of Pond Apple Slough can be attributed to the fact that it is part of the forested drainageway formed near the New River break in the coastal ridge, along the edge of the remnant Everglades. Most wetlands in eastern Broward County are man-made excavated systems, generally less than five acres in size. The health of Pond Apple Slough was impaired when its natural overland flow of fresh water was greatly diminished due to years of development and construction of Interstate 595 (I-595), the Broward County Resource Recovery Center, and the I-595/State Road 441 interchange. The South Florida Water Management District (District), along with Broward County and other interested parties, has been a participant in the Pond Apple Slough Working Group, an association created in 1991, dedicated to restoration of the slough.

The work of the PAS Working Group was funded by mitigation funds made available to Broward County in a 1991 agreement with the Homart Development Corporation. This work included a baseline study to determine the health and needs of the slough, removal of exotics from the area, and development of a long-term management plan to maintain a healthy, freshwater ecosystem. The PAS Working Group agreed that a permanent and stable supply of fresh water was needed for the slough. Based on this recommendation, the District, with concurrence from Broward County, agreed to use funds from a KMart™ mitigation agreement (Permit 06-00898-S-11) to fund the construction of a freshwater delivery system for Pond Apple Slough. The system, as designed, will divert water from the District's C-11 canal, through culverts, to Pond Apple Slough. The design of the system is now completed, and the contractor is in the process of obtaining necessary permits before beginning construction.

This report is intended to compile a summary of pertinent Pond Apple Slough information into one document. The report provides an overview of the Pond Apple Slough Ecosystem, a brief history of the restoration project, and a compilation of data collected by the District and Broward County staff. These data include water quality measurements from the slough, water levels (ground and surface) from sites in and near the slough, monitor well location and elevation information, and flow from structures located near the slough. Subsequent reports will be provided by the contractor.

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Appreciation is extended to the many South Florida Water Management District (District) staff who participated in the project or helped with the compilation of data and production of this report. They include John Lukasiewicz, Nancy Demonstranti, Emily Hopkins, Eduardo Lopez, Angela Chong, Brenda Mills, Chris McVoy, Susan Coughanour, and Barb Conmy. Jim Karas, formerly with the District, currently with Broward County, provided information and editorial assistance. We thank the staff at the Fort Lauderdale Field Station for its time and effort with the rehydration test, and Kim Jacobs for her assistance in preparing this report for publication.

INTRODUCTION

Pond Apple Slough is a 112-acre remnant freshwater urban wetland in the eastern portion of Broward County, Florida (Lewis, 1996). As an urban wetland, Pond Apple Slough helps to absorb flood water, naturally filter water, and provide a refuge for wildlife in the midst of development. Over many years, development diverted the natural flow of water to the slough, causing its health to deteriorate. A decrease in natural overland flow allowed the intrusion of salt water, causing the deaths of cypress trees from salt stress, the invasion of mangroves into historic freshwater areas, and the toppling of pond apple trees due to marine isopods eating the pond apple roots. This deterioration prompted concerns by a number of public agencies and private organizations. Efforts to restore Pond Apple Slough appear to have begun in 1986, during the construction of the Interstate 595 (I-595) overpass.

The South Florida Water Management District (District) began working with Broward County in early 1991 to find a reliable source of fresh water for the slough and became an active participant in the Pond Apple Slough Working Group (BCWRMD, 1991). The working group was comprised of Broward County and District staff, as well as other individuals with an interest in the condition and restoration of Pond Apple Slough. In 1992, the working group contracted with Lewis Environmental to develop a long-term plan for restoration and management of the slough and, in 1995, the District approved the use of mitigation funds (Permit 06-00898-S-11) to help provide a permanent supply of fresh water to Pond Apple Slough. In 1997, the District established a cooperative agreement with Broward County to complete the project. The water delivery system has now been designed, and the contractor is in the process of applying for all necessary permits. The system is scheduled to be constructed in 2001.

Location and Geography

Pond Apple Slough is about six miles west of the Atlantic Ocean, west of the Atlantic Coastal Ridge, in eastern Broward County. The slough is a part of the Pond Apple Slough Ecosystem, which includes about 750 acres on both sides of the South New River Canal in southern Broward County (Lewis, 1996). The Pond Apple Slough ecosystem was originally a part of the flowway system connecting the Everglades to the New River and contained mixed forest vegetation with stands of sawgrass (Lewis, 1996). The elevation of Pond Apple Slough ranges from +5.0 feet National Geodetic Vertical Datum of 1929 (NGVD) at the northwestern corner, to 0.0 feet, where the slough meets the South New River Canal (Lewis, 1996; BCONRP, 1992). When the water level in the South New River is high, the eastern and central areas of the slough are inundated with water.

The slough is bordered by I-595 to the north, the South New River Canal (C-11 canal) to the south and east, and the 58-acre Griffey Tract to the west. Immediately west of the Griffey Tract is the Broward County Resource Recovery Facility, including a large ash residue landfill. The Florida Power and Light Fort Lauderdale Power Plant is on the southern side of the South New River Canal.

The District's G-54 structure is on the North New River, west of the Florida Turnpike, while the S-13 structure is on the South New River, west of the slough. West of the Resource Recovery Facility are several rock pits, artificial lakes, and the Central Broward Water Control District's N-1 canal. The N-1 canal connects to the District's C-11 canal, west of the S-13 structure. **Figure 1** shows a map of the area.

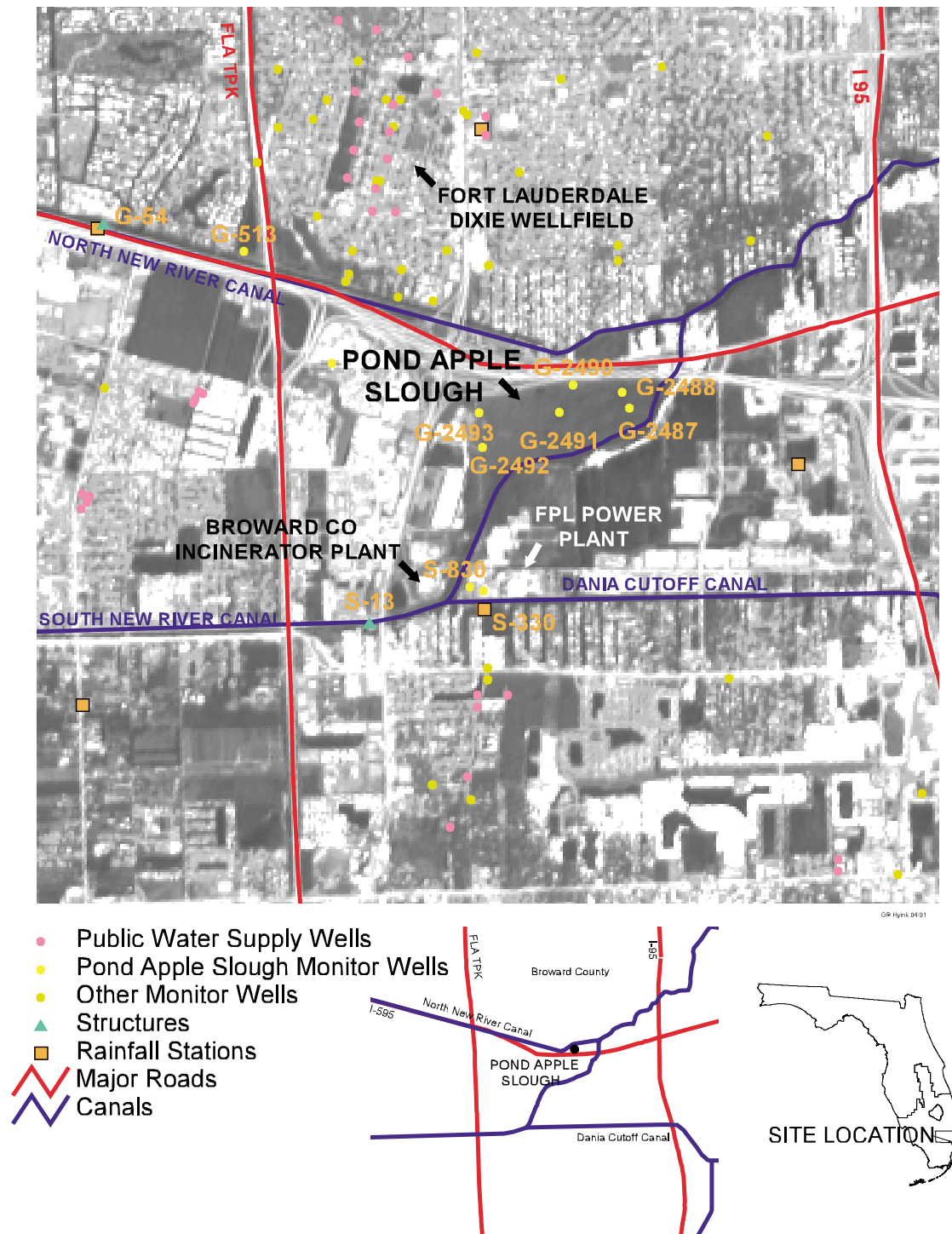


Figure 1. Map of Pond Apple Slough

Vegetation

The changes in vegetation were one of the key indicators that the health of Pond Apple Slough was in jeopardy. It had been observed by working group participants that freshwater cypress trees were dying off, mangroves were moving in, and exotic species (such as Australian pine and melaleuca) were intruding. As a step in the development of the Pond Apple Slough Management Plan, Lewis Environmental completed a vegetation inventory in 1996 (Lewis, 1996).

The results of the inventory indicate that, at the time, the Pond Apple Slough tree canopy was primarily pond apples with a leather fern understory (Lewis, 1996). Red and white mangroves had moved into the tidal portions of the slough, indicating saltwater intrusion into the historically fresh surface water. The changing environment caused the deaths of freshwater cypress trees due to salt stress, and the deaths of pond apple trees because of an isopod boring into roots of the trees. The upper elevations of the slough were inhabited by sawgrass, cattails, and some bald cypress and exotics, such as Brazilian pepper, Australian pine, and melaleuca (Lewis, 1996). [Figure 2](#) shows the results of the vegetation inventory.

Hydrogeology

In South Florida, the primary source of fresh water is the unconfined Surficial Aquifer System (SAS), which is comprised of all saturated sediments from ground surface to the Hawthorn Group. The Hawthorn Group is a thick sequence of relatively impermeable clayey sediments (Giddings, 1999; Scott, 1992; SFWMD, 1991). The highly transmissive Biscayne aquifer is part of the SAS, underlies central and eastern Broward County, and consists primarily of sediments considered to be Pleistocene in age (Parker et al., 1955; Leach, 1972). The thickness of the Biscayne Aquifer increases in Broward County from west to east. It is about 10 feet in the western part of the county, and thickens to about 200 feet in the Fort Lauderdale area (Leach, 1972; Hoffmeister, 1974).

According to the Florida Department of Transportation, a 1-foot layer of organic muck is on the surface of the slough (BCONRP, 1992). In eastern Broward County, this organic muck overlies the Pamlico sand (Finkl and Esteves, 1997; Parker et al., 1955; Hoffmeister, 1974). This low to medium permeability sand is carbonaceous quartz and is frequently very fossiliferous. In some areas, the Pamlico sand is clean and well sorted, while in other areas, it is poorly sorted with intermixed finer sand grains, silt, and organic materials. The sand is primarily gray-white to brown or black and is Pleistocene in age (Hoffmeister, 1974).

Underlying the Pamlico sand is the Miami limestone that forms the southern portion of the Atlantic Coastal Ridge. The Miami limestone has an oolitic facies overlying a bryozoan facies (Hoffmeister, 1974; Scott, 1992). The Miami limestone is also considered to be Pleistocene, is porous with large solution holes, and demonstrates high vertical permeability with lower horizontal permeability (Parker et al., 1955; Hoffmeister, 1974). In central Broward County, the oolitic facies grades into the Anastasia Formation. The

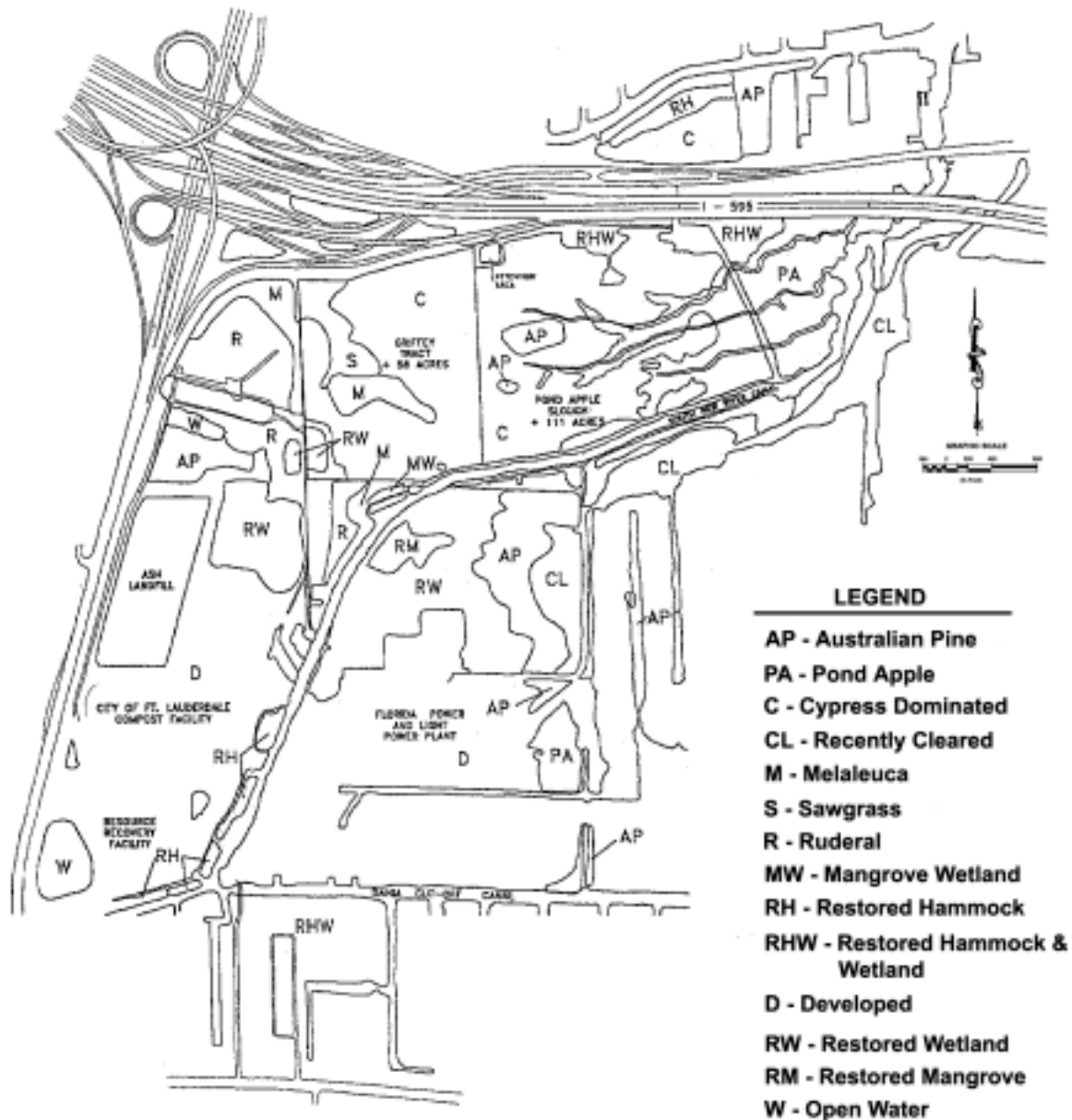


Figure 2. Vegetation in Pond Apple Slough Ecosystem (Lewis, 1996)

Anastasia Formation is Pleistocene in age (Parker et al., 1955) and may be as thick as 100 feet toward the coast, while thinning to the west. The Anastasia Formation is primarily sandy limestone, calcareous sandstone, fossiliferous calcareous quartz sand, shells, and coquina (Hoffmeister, 1974; Scott, 1992).

Underlying the Anastasia Formation is the upper Miocene Tamiami Formation. In Broward County, the Tamiami is comprised of a thin layer of nonoolitic limestone and a thick section of greenish clay marl, silty shelly limestone, and calcareous marl to limestone (Parker et al., 1955; Giddings, 1999). The impermeable Hawthorn Formation underlies the Tamiami and forms the base of the Biscayne aquifer (Parker et al., 1955;

Scott, 1992; Giddings, 1999). The Hawthorn Formation is comprised of greenish clays, marls, silts, and sand with some quartzite and phosphate pebbles and is lower/middle Miocene (Parker et al., 1955). The greenish clays of the Hawthorn and Tamiami formations require the identification of macrofossils to accurately differentiate between them.

POND APPLE SLOUGH HYDROLOGY

In the past, it was likely the Pond Apple Slough ecosystem watershed encompassed several thousand acres, while serving as an eastern Everglades drainage path during periods of high water. In rainy periods, water would move across the entire system as sheetflow from the west to the east (Lewis, 1996). Beginning in 1905, the normal overland flow of fresh water to Pond Apple Slough was diminished with the dredging of the North and South New River Canals. The dredging project began near the headwaters of the South Fork of the New River and worked westward (Anonymous, 1907). The spoil material from the dredging was used to construct a berm adjacent to the river (canal), forming a barrier between the New River and the wetlands.

Water was now allowed to flow steadily from Lake Okeechobee and the northern Everglades, through the open North New River Canal and into the Atlantic Ocean (Leach, 1972). This open canal system permitted the water to flow continually and surface water stages, including those in the slough, were reduced. After a drought period from 1943 through 1945, control structures were added to the major canals through the coastal ridge to allow management of the flow and water levels (Leach, 1972).

Saltwater intrusion from tidal flow in the canal was not a problem before completion of the water conservation areas (WCAs) west of the Pond Apple Slough ecosystem. The previously high levels of eastward flow through the North New River Canal had controlled the inland tidal flow. After completion of the WCAs, much of the water that had flowed eastward in the canal was now retained in the WCAs. With eastward flow in this canal now reduced by as much as 25 percent, the saline tidal water was able to travel further upstream and into the slough (Leach, 1972). Because parts of the slough are inundated with water when the South New River is high, brackish water was able to move into the slough surface water. The higher density of the salt water allowed the movement of this water into the shallow groundwater (BCONRP, 1992).

Construction of the Broward County Resource Recovery facility in the 1980s also had a negative impact on slough hydrology. As part of this project, over 97 acres of freshwater wetland west of the Griffey Tract were filled, drainage to the slough was diminished, and portions of the berm on the western side of the South New River Canal were removed (Lewis, 1996). Removal of the berm, though approved, facilitated the intrusion of salt water into the slough, damaging the cypress population. The construction of I-595 again reduced the area of the slough and the amount of available fresh water (Lewis, 1996). As a result of these activities, Pond Apple Slough was greatly reduced in size and supplied with a very limited supply of fresh water.

As a part of wetland mitigation for the I-595 construction projects, the Florida Department of Transportation purchased Pond Apple Slough and an additional 22.5 acres that run along the South New River Canal. The plan was to restore these two areas and the Griffey Tract, oversee removal of exotic plant species, and turn the land over to Broward County at the completion of the interstate. Pond Apple Slough was deeded to Broward County in September 1998, and is now managed by the Broward County Parks and Recreation Division (BCDNP, 2000).

Pond Apple Slough Restoration Project

Broward County began studying Pond Apple Slough restoration in 1988 when the Broward County Environmental Quality Control Board and the United States Geological Survey began a hydrologic study of the slough. The results of this study indicated that in drought conditions, the groundwater and surface water within the slough was considered low to moderately brackish and within the tolerance range of pond apples, but not cypress trees (BCEQCB, 1990). The study also showed the discharge of fresh water (from the G-54 structure) to tide had been decreasing over the years. In 1989, the average daily flow rate was 5 cubic feet per second (cfs), while the 10-year annual average was 154 cfs, and the 49-year annual average was 358 cfs.

Broward County Water Resources Management Division staff drafted a report in 1990 that reviewed the cause of the Pond Apple Slough problems and tried to identify a potential solution to the freshwater problem. As described in this report, water would be diverted from the C-11 structure through a series of existing culverts, under State Road 7, and into a new pond situated in the northwestern corner of Pond Apple Slough. Because the source of the fresh water is lower in elevation than Pond Apple Slough, a pump would be necessary to lift the water through all the culverts (BCWRMD, 1990). Construction costs would be contained by using existing culverts, as appropriate. The final plan design has changed somewhat from the original plan in the use of existing culverts and method of water delivery. Details regarding the revised design are provided in the District's Surface Water Permit Application 001220-8.

In 1991, Broward County and the United States Army Corps of Engineers received \$300,000 from Homart Development Company to settle a wetlands violation case. It was agreed to use this money to restore the Pond Apple Slough ecosystem. That same year, the Pond Apple Slough Working Group was formed to provide oversight for the planning efforts (BCEQCB, 1990). In 1992, Lewis Environmental Services was hired to review the proposed restoration plan, develop a long-term management plan for the slough, and oversee work, such as the removal of exotic plants. The proposed restoration plan had listed five key tasks that would need to be conducted to complete the restoration (Lewis, 1996):

1. Redirect retention pond discharge away from the existing direct stream discharge
2. Block the known breach (and any other confirmed breaches) in the South New River berm

3. Coordinate exotic plant control efforts in the area
4. Seek additional sources of fresh water for the slough
5. Investigate the need of constructing additional berms, as appropriate

By December 1996, a long-term management plan was developed, and the first three key tasks had been completed (Lewis, 1996). The working group decided to install five shallow 2-inch monitor wells to monitor current and future groundwater levels and water quality. The design of the proposed freshwater delivery system was in process, but slowed by lack of detailed topographic data. The topographic data were not available, and many working group members were against a survey because of the destructive trail blazing involved. Therefore, District staff proposed a temporary rehydration test to simulate the suggested plan and provide the following:

- Determine the general topography in the vicinity of the proposed recharge area by following the flow of the water
- Estimate the effects of the proposed discharge at the monitoring stations by establishing pumpage rates close to the proposed discharge rates
- Evaluate the temporary pumping effects by monitoring the groundwater and surface water levels with data loggers

The test was scheduled for late summer 1997. Before beginning the test, the five monitor wells were installed and constructed by Hydrologic Associates, Inc. under contract with Broward County and with direction from the Pond Apple Slough Working Group. The wells were situated in the center and in the four corners of the slough to obtain data representative of the entire area. Well construction details are provided in [Appendix A](#) of this report. Lithologic data are not available.

In the test, water was periodically pumped by District staff from the northwestern corner of the Griffey Tract into the slough, from September 4 to September 19, 1997. The pump was operated manually and was maintained by the District's Fort Lauderdale Field Station staff. The pump had a capacity of 1,460 gallons per minute (gpm). The rehydration pump schedule is provided in [Table 1](#).

Table 1. Rehydration Pump Schedule

| | 9/4 | 9/5 | 9/8 | 9/8 | 9/9 | 9/9 | 9/10 | 9/10 | 9/11 | 9/11 | 9/12 | 9/15 | 9/15 | 9/16 | 9/17 | 9/19 |
|---------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Time Pump On | 11:30 | 8:00 | 8:00 | 12:30 | 8:15 | 13:00 | 8:00 | 13:00 | 8:30 | 14:00 | 8:00 | 9:30 | 12:30 | 9:00 | 8:00 | 8:00 |
| Time Pump Off | 14:00 | 14:15 | 10:30 | 14:30 | 10:45 | 15:15 | 10:30 | 14:30 | 10:00 | 14:45 | 10:00 | 11:30 | 14:00 | 10:30 | 10:00 | 10:30 |

In-situ™ data loggers with 10 pounds per square inch (psi) pressure transducers were placed at the southwestern well (MW-3A-S) and the center well (MW-5A-S) on September 3, 1997, to monitor water levels during the test. The test began on September 4, 1997. Surface water and groundwater levels were measured and recorded every 15 minutes for the test duration. The data showed minimal water level changes between the times the pump was on and off. The differences ranged between 0.0 and 0.2 feet. These data, in graphical form, are provided in the appendices of this report. Possible reasons for this minimal effect is likely a combination of the following:

- Pump capacity was too small for the area and volume of water involved
- Individual pumping periods were not long enough
- Volume of groundwater recharge throughout the slough was greater than the volume of pumped water
- Upper layers of the aquifer have very high levels of hydraulic conductivity
- Tidal effect was so great that it dampened the overall effect of the pumping test

While the minimal effects of the additional surface water could be viewed as disappointing, it was not unexpected, due to the highly transmissive nature of the aquifer. The total volume of water pumped during the 16 days of the test was about 3.1 million gallons (9.5 acre-feet). The pump that will be used in the recharge plan has a greater capacity. The District anticipates that 1,000 to 1,350 acre-feet of water will be pumped into the slough annually (Hydrologic Associates, 2001a). The Pond Apple Slough Working Group believes the recharge plan will provide sufficient water on a stable basis to protect the health of the slough and stabilize the areas of cypress (Hydrologic Associates, 2001b).

To obtain baseline water quality data, District staff measured temperature, specific conductivity, dissolved oxygen, pH, and salinity at wells located in the Griffey Tract and at several of the new Pond Apple Slough monitor wells in 1996 and 1997. Dissolved oxygen levels in a number of wells including MWC-2C-A, MW-6A-S, and MW-7A-S exceed 3.2 milligrams per liter (mg/l), indicating surface water influence. Specific conductivity levels ranged from a low of about 700 microseonds per centimeter ($\mu\text{S}/\text{cm}$) to a high of nearly 10,000 $\mu\text{S}/\text{cm}$. Specific conductivity was measured more than once at three wells, but we do not have salinity measurements for each from the same days. Two of these wells show specific conductance differences in excess of 3,000 $\mu\text{S}/\text{cm}$, which could indicate groundwater influence that is dependent on the level of the surface water. Detailed results are provided in [Appendix A, Table A-3](#).

Samples were collected and analyzed for major ions, nutrients, and metals from the five new monitor wells ([Table 2](#)). These samples were collected by Broward County staff in September 1997 and analyzed by the Broward County Laboratory. The results of the metals analysis were all below detection limits, except for wells MW-3A-S, MW-4A-2, and MW-7A-S, which had chromium levels slightly above the detection limit. The differences in major ion values indicate some wells have different sources of water. However, as sulfate was not measured, it is not possible to do a tri-linear diagram or ionic balance. Details of all water chemistry results are provided in [Appendix A, Table A-3](#).

Table 2. Summary of Water Chemistry at Pond Apple Slough^{a b}

| Site ID | Type | Sample Depth (feet) | Spec. Cond. ^c (μS/cm) | Na (mg/l) | Ca (mg/l) | K (mg/l) | Mg (mg/l) | Cl (mg/l) | TKN (mg/l) | NO ₂ +NO ₃ (mg/l) | Total P (mg/l) | Cr (μg/L) |
|------------|---------|---------------------|----------------------------------|-----------|-----------|----------|-----------|-----------|------------|---|----------------|-----------|
| Borrow pit | Surface | | 2,380 | 285.5 | 39.4 | 6.20 | 14.2 | 578 | - | - | - | - |
| Borrow pit | Surface | 4.7 | 2,400 | 358.5 | 91.6 | 17.6 | 33.4 | 588 | - | - | - | - |
| MW-3A-S | Well | - | 2,600 | 128.0 | 100 | 21.5 | 37.0 | 694 | 1.52 | 0.022 | 0.073 | 5.65 |
| MW-4A-S | Well | - | 3,360 | 450.0 | 187.0 | 10.3 | 21.2 | 851 | 3.99 | < 0.0180 | 0.081 | 6.68 |
| MW-5A-S | Well | - | 2,400 | 119.0 | 143.0 | 11.9 | 25.2 | 578 | 1.65 | 0.019 | 0.044 | < 5.27 |
| MW-6A-S | Well | - | 800 | 34.5 | 64.8 | 12.2 | 20.2 | 76.0 | 3.16 | 0.033 | 0.061 | < 5.27 |
| MW-7A-S | Well | - | 9,910 | 1,660.0 | 164.0 | 97.9 | 141 | 2,940 | 1.68 | 0.02 | 0.102 | 5.34 |

- a. Surface water samples were obtained on February 14, 1997, and groundwater samples were obtained on September 3, 1997.
- b. Element and compound abbreviations are defined in [Table A-3](#)
- c. Spec. Cond. = Specific Conductance

Broward County and the Pond Apple Slough Working Group ([Table 3](#)) are currently involved in finalizing the system design and obtaining permits to construct and operate the freshwater delivery system. The design plans include a pump capable of moving 2,500 to 3,000 gpm or 3.6 to 4.3 million gallons per day (MGD) (Hydrologic Associates, 2001). The contractor is currently in the process of obtaining the necessary permits. The schedule dated for construction completion and inspection is August 2001 with the system operational in August 2002.

Table 3. Pond Apple Slough Working Group

| Member | Affiliation |
|--------------------|--|
| Jim Breitenstein | City of Fort Lauderdale |
| Don Burgess | Broward County Department of Planning and Environmental Protection |
| Laura Burnett | Florida Department of Transportation |
| Heather Carman | Broward County Department of Planning and Environmental Protection |
| Kathy Cartier | Broward County Department of Planning and Environmental Protection |
| Don Charlton | Broward County Office of Environmental Services |
| Dan Cotter | Secret Woods Nature Center |
| Wendy Cyriaks | Florida Department of Transportation |
| Gordon Dively | Broward County Department of Planning and Environmental Protection |
| Becky Fierle | Broward County Water Resources Management Division |
| Jim Goldasich | J.J. Goldasich & Associates |
| Jim Hamilton | Broward County Parks and Recreation Division |
| Bob Harbin | Broward County Parks and Recreation Division |
| Tom Henderson | Broward County Office of Integrated Waste Management |
| Steve Higgins | Broward County Department of Planning and Environmental Protection |
| Jim Karas | South Florida Water Management District |
| Teri Klonsky, P.E. | SKS Engineering, Inc. |
| Steve Krupa | South Florida Water Management District |
| Angela Lucci | Broward County Department of Planning and Environmental Protection |
| Gil MacAdam | Broward County Parks and Recreation Division |
| Dave Markward | Broward County Office of Environmental Services |

Table 3. Pond Apple Slough Working Group (Continued)

| Member | Affiliation |
|---------------------|---|
| Larry Marvet | Sierra Club |
| Frank Mazzotti | University of Florida's Institute of Food and Agricultural Sciences |
| Carlton Miller | Broward County Office of Integrated Waste Management |
| Cynthia Morani | South Florida Water Management District |
| Carol Morgenstern | Broward County Parks and Recreation Division |
| Eric Myers | Broward County Department of Planning and Environmental Protection |
| Howard Nelson, Esq. | Eckert, Seamans, P.A. |
| Mike Nichols | Craven Thompson |
| Gerald Peters | Broward County |
| Monica Ribaudo | Broward County Parks and Recreation Division |
| Al Sifferlen | City of North Lauderdale |
| Ram Tevari | Broward County |
| Linda White | Broward County Parks and Recreation Division |
| Woody Wilkes | Museum of Discovery and Science |
| Gangpen Zhang | Broward County Department of Planning and Environmental Protection |

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APPENDIX A

Pond Apple Slough Charts and Data

This appendix provides charts and data to support the Pond Apple Slough report. A site map of the Pond Apple Slough is shown in **Figure A-1**. The Pond Apple Slough monitor well construction table is provided in **Table A-1**, and water levels in the Pond Apple Slough ecosystem are shown in **Table A-2**. Water chemistry results are shown in a table (**Table A-3**) and in a series of five charts (**Figures A-2 through A-6**). The MS-3A-S and MW-5A-S water level charts are shown in **Figures A-7 through A-9**, and **Figures A-10 through A-12**, respectively. The flow data at the G-54, G-54S, and S-13 structures are provided in **Tables A-4 through A-7**.

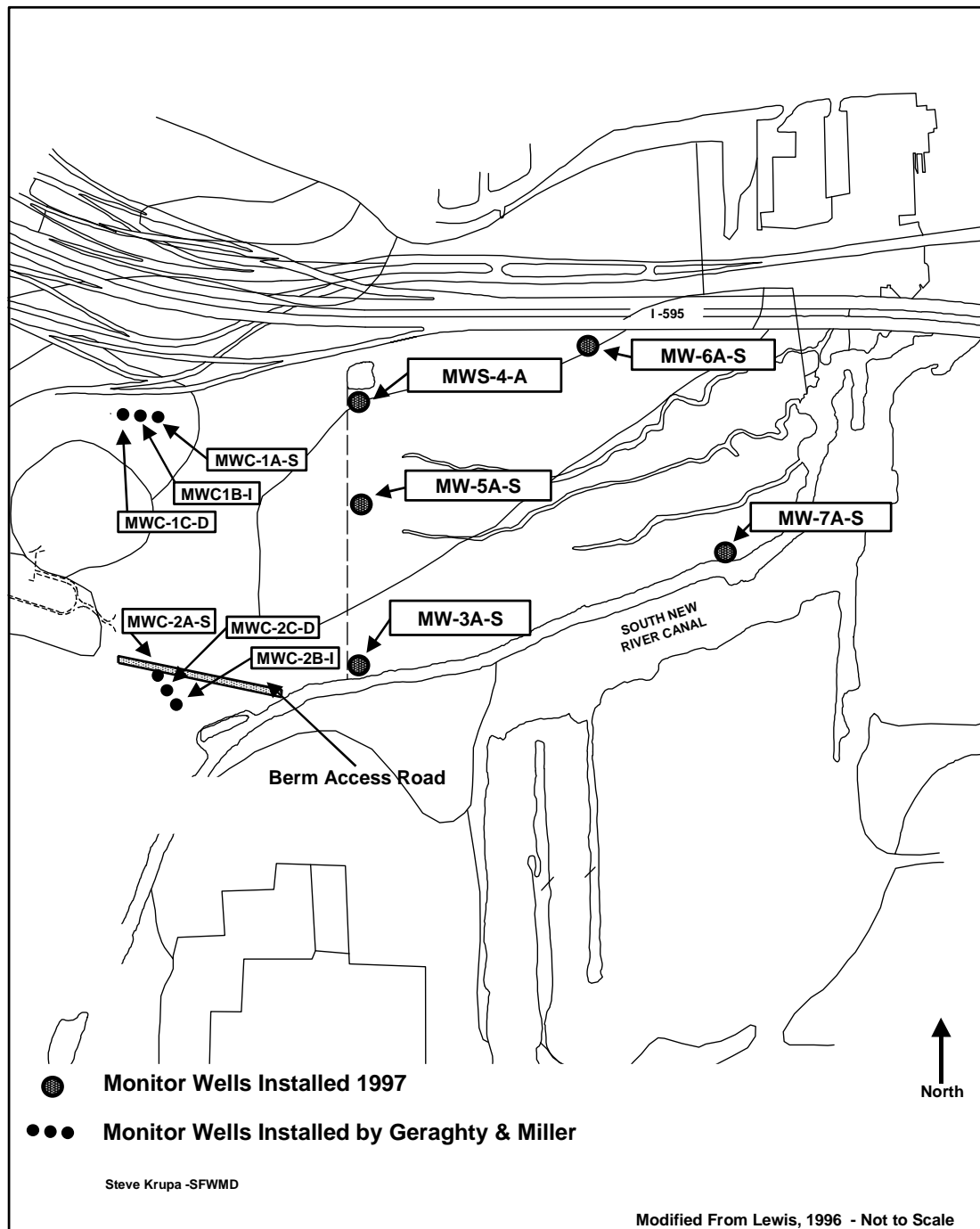


Figure A-1. Pond Apple Slough Site Map

Table A-1. Construction Table for Pond Apple Slough Ecosystem Monitor Well^a

| Well Name | Alternative Name | Source ^b | Well Location ^c | Well Installation Date | Elevation (feet NGVD) | | | | | Total Well Depth (feet) | Screen Length (feet) |
|---------------|------------------|---------------------|----------------------------|------------------------|-----------------------|---------------------|----------------|---------------|------------------|-------------------------|----------------------|
| | | | | | Top of Inner Casing | Top of Outer Casing | Ground Surface | Top of Screen | Bottom of Screen | | |
| Griffey Tract | | | | | | | | | | | |
| MWC-1A-S | 6S | G&M | NW corner | October 1985 | 3.49 | ND ^d | 1.57 | -1.45 | -3.45 | 6.94 | 2 |
| MWC-1B-I | 5I | G&M | NW corner | October 1985 | 3.42 | ND | 1.63 | -13.28 | -23.28 | 26.70 | 10 |
| MWC-1C-D | 4D | G&M | NW corner | October 1985 | 3.29 | ND | 1.61 | -38.31 | -48.31 | 51.60 | 10 |
| MWC-2A-S | 9S | G&M | SW corner | October 1985 | 4.70 | ND | 2.05 | -0.30 | -2.30 | 7.00 | 2 |
| MWC-2B-I | 8I | G&M | SW corner | October 1985 | 4.34 | ND | 2.00 | -13.46 | -23.46 | 27.80 | 10 |
| MWC-2C-D | 7D | G&M | SW corner | October 1985 | 4.05 | ND | 1.96 | -34.75 | -44.75 | 48.80 | 10 |
| Ecotone | | | | | | | | | | | |
| MW-3A-S | | BC | SW corner | June 1997 | 4.94 | 5.25 | ND | -4.16 | -14.16 | 19.10 | 10 |
| MW-4A-S | | BC | NW corner | June 1997 | 4.39 | 4.92 | ND | -2.20 | -12.20 | 16.59 | 10 |
| MW-5A-S | | BC | Center | June 1997 | 4.66 | 4.83 | ND | -1.72 | -11.72 | 16.38 | 10 |
| MW-6A-S | | BC | NE corner | June 1997 | 5.92 | 6.40 | ND | -1.21 | -11.21 | 17.13 | 10 |
| MW-7A-S | | BC | SE corner | June 1997 | 5.28 | 5.58 | ND | -2.41 | -12.41 | 17.69 | 10 |

a. All wells are constructed of 2-inch PVC

b. G&M = Geraghty & Miller; BC = Broward County

c. NE = northeastern; NW = northwestern; SE = southeastern; SW = southwestern

d. ND = no data available

Table A-2. Water Levels in the Pond Apple Slough Ecosystem^a

| Well Name | Alternate Name | Position in Cluster | State Planar 1927 Datum (feet) | | Latitude | Longitude | Well Location ^b | Water Levels (1929 feet NGVD) | | Depth to Water 9/3/97 (feet) |
|---------------|----------------|---------------------|--------------------------------|------------|---------------|---------------|----------------------------|-------------------------------|---------|------------------------------|
| | | | Easting | Northing | | | | 9/3/97 | 10/6/97 | |
| Griffey Tract | | | | | | | | | | |
| MWC-1A-S | MWC-1C-S | East | ND ^c | ND | ND | ND | NW corner | 2.25 | ND | |
| MWC-1B-I | MWC-1C-B | Center | ND | ND | ND | ND | NW corner | 2.00 | ND | |
| MWC-1C-D | MWC-1C-A | West | ND | ND | ND | ND | NW corner | 1.89 | ND | |
| MWC-2A-S | MWC-2C-S | North | ND | ND | ND | ND | SW corner | 1.78 | ND | |
| MWC-2B-I | MWC-2B-I | Center | ND | ND | ND | ND | SW corner | 2.08 | ND | |
| MWC-2C-D | MWC-2A-D | South | ND | ND | ND | ND | SW corner | 1.49 | ND | |
| Ecotone | | | | | | | | | | |
| G-2492 | USGS well | | ND | ND | ND | ND | Center | ND | ND | -1.86 |
| MW-3A-S | | | 920314.037 | 634810.57 | 26 04 40.3528 | 80 11 42.9415 | SW corner | ND | 1.26 | ND |
| MW-3A-SW | | | ND | ND | 26 04 40.3528 | 80 11 42.9415 | Near MW-3A-S | ND | 0.30 | ND |
| MW-4A-S | | | 920146.421 | 636453.123 | 26 04 56.6306 | 80 11 44.6686 | NW corner | ND | ND | ND |
| MW-5A-S | | | 920187.484 | 635573.991 | 26 04 47.9213 | 80 11 44.2777 | Center | ND | 1.61 | ND |
| MW-5A-SW | staff gage | | ND | ND | 26 04 47.9213 | 80 11 44.2777 | Near MW-5A-S | ND | 2.62 | ND |
| MW-6A-S | | | 921872.597 | 636874.577 | 26 05 00.6988 | 80 11 25.7086 | NE corner | ND | ND | ND |
| MW-7A-S | | | 922990.576 | 635519.345 | 26 04 47.2079 | 80 11 13.5402 | SE corner | ND | ND | ND |

a. The staff gage on the South New River (near MW-3A-S) is set one-foot high. Measurements have been corrected.

b. NE = northeastern; NW = northwestern; SE = southeastern; SW = southwestern

c. ND = no data available

Table A-3. Water Chemistry at Pond Apple Slough

| Site Name | Sample Name | Type | Sample Date ^a | Number of Samples | Sample Depth (feet) | Temperature (°C) | Specific Conductivity (microseconds/cm) | Dissolved Oxygen (percent) | Dissolved Oxygen (mg/l) | pH | Salinity (parts per trillion) | Oxidation Reduction Potential (millivolt) |
|-----------------|-------------|---------|--------------------------|-------------------|---------------------|------------------|---|----------------------------|-------------------------|------|-------------------------------|---|
| MWC-1C-A | PAS1 | Well | 10/31/96 | 5 | 48.75 | 24.06 | 718 | 12.9 | 1.06 | 6.73 | - | - |
| MWC-1C-B | PAS2 | Well | 10/31/96 | 5 | 22.80 | 23.83 | 722 | 11.5 | 0.97 | 6.75 | - | - |
| MWC-1C-C | PAS3 | Well | 10/31/96 | 6 | 4.86 | 24.71 | 748 | 9.6 | 0.79 | 6.80 | - | - |
| MWC-2C-SW | PAS4 | Surface | 10/31/96 | 1 | 0.23 | 24.89 | 764 | 31.2 | 2.58 | 7.27 | - | - |
| MWC-2C-C | PAS5 | Well | 10/31/96 | 14 | 44.40 | 23.92 | 3,356 | 17.0 | 1.12 | 7.04 | 1.76 | - |
| MWC-2C-B | PAS6 | Well | 10/31/96 | 13 | 23.67 | 23.93 | 3,107 | 26.4 | 2.20 | 6.91 | 1.62 | - |
| MWC-2C-A | PAS7 | Well | 10/31/96 | 9 | 3.65 | 26.00 | 994 | 40.6 | 3.29 | 6.86 | 0.49 | - |
| MW-3A-S (8/97) | SE well | Well | 08/02/97 | 9 | 6.69 | 25.31 | 8,616 | 5.7 | 0.46 | 6.69 | 4.79 | -26 |
| MW-6A-S (10/96) | PAS8 | Well | 10/31/96 | 9 | 2.80 | 31.22 | 2,715 | 88.3 | 6.48 | 7.42 | 1.39 | - |
| MW-6A-SW | PAS9 | Surface | 10/31/96 | 6 | 0.13 | 27.45 | 1,082 | 74.1 | 5.84 | 7.50 | 0.53 | - |
| MW-7A-S (10/96) | PAS13 | Well | 10/31/96 | 5 | 0.24 | 27.45 | 1,262 | 60.6 | 4.77 | 7.20 | 0.63 | - |
| G-2487 | PAS17 | Well | 10/31/96 | 1 | 6.91 | 25.71 | 3,007 | 26.5 | 2.14 | 6.91 | 1.56 | -332 |
| Borrow pit | 97N60634-SW | Surface | 02/14/97 | 2 | 0.5? | - | 2,380 | - | - | - | 1.2 | - |
| Borrow pit | 97N60635-SW | Surface | 02/14/97 | 2 | 4.7 | - | 2,400 | - | - | - | 1.3 | - |
| MW-3A-S (9/97) | - | Well | 09/03/97 | 1 | - | - | 2,600 | - | - | - | - | - |
| MW-4A-S | - | Well | 09/03/97 | 1 | - | - | 3,360 | - | - | - | - | - |
| MW-5A-S | - | Well | 09/03/97 | 1 | - | - | 2,400 | - | - | - | - | - |
| MW-6A-S (9/97) | - | Well | 09/03/97 | 1 | - | - | 800 | - | - | - | - | - |
| MW-7A-S (9/97) | - | Well | 09/03/97 | 1 | - | - | 9,910 | - | - | - | - | - |

a. Samples from October 31, 1996, and August 2, 1997, were collected by SFWMD staff using a YSI water quality sensor (model 610DM handheld unit attached to a 600XL sonde). Samples from February 14, 1997, and September 30, 1997, were collected and analyzed by Broward County staff.

Table A-3. Water Chemistry at Pond Apple Slough (Continued)

| Site Name | Sample Name | Sodium (Na) | Calcium (Ca) | Potassium (K) | Magnesium (Mg) | Chlorine (Cl) | Total Kjeldahl Nitrogen (TKN) | Nitrate + Nitrite (NO ₂ + NO ₃) | Total Phosphorus (Total P) | Lead (Pb) | Nickel (Ni) | Copper (Cu) | Zinc (Zn) | Cadmium (Cd) | Chromium (Cr) |
|-----------------|-------------|-------------|--------------|---------------|----------------|---------------|-------------------------------|--|----------------------------|-----------|-------------|-------------|-----------|--------------|---------------|
| | | mg/l | | | | | | | | µg/l | | | | | |
| MWC-1C-A | PAS1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| MWC-1C-B | PAS2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| MWC-1C-C | PAS3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| MWC-2C-SW | PAS4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| MWC-2C-C | PAS5 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| MWC-2C-B | PAS6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| MWC-2C-A | PAS7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| MW-3A-S (8/97) | SE well | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| MW-6A-S (10/96) | PAS8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| MW-6A-SW | PAS9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| MW-7A-S (10/96) | PAS13 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| G-2487 | PAS17 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Borrow pit | 97N60634-SW | 285.5 | 39.4 | 6.2 | 14.2 | 578 | - | - | - | - | - | - | - | - | - |
| Borrow pit | 97N60635-SW | 358.5 | 91.6 | 17.6 | 33.4 | 588 | - | - | - | - | - | - | - | - | - |
| MW-3A-S (9/97) | - | 128.0 | 100.0 | 21.5 | 37.0 | 694 | 1.52 | 0.022 | 0.073 | <22.0 | <13.5 | <10.4 | <16.0 | <2.47 | 5.65 |
| MW-4A-S | - | 450.0 | 187.0 | 10.3 | 21.2 | 851 | 3.99 | <0.0180 | 0.081 | <22.0 | <13.5 | <10.4 | <16.0 | <2.47 | 6.68 |
| MW-5A-S | - | 119.0 | 143.0 | 11.9 | 25.2 | 578 | 1.65 | 0.019 | 0.044 | <22.0 | <13.5 | <10.4 | <16.0 | <2.47 | <5.27 |
| MW-6A-S (9/97) | - | 34.5 | 64.8 | 12.2 | 20.2 | 76 | 3.16 | 0.033 | 0.061 | <22.0 | <13.5 | <10.4 | <16.0 | <2.47 | <5.27 |
| MW-7A-S (9/97) | - | 1,660.0 | 164.0 | 97.9 | 141.0 | 2,940 | 1.68 | 0.02 | 0.102 | <22.0 | <13.5 | <10.4 | <16.0 | <2.47 | 5.34 |

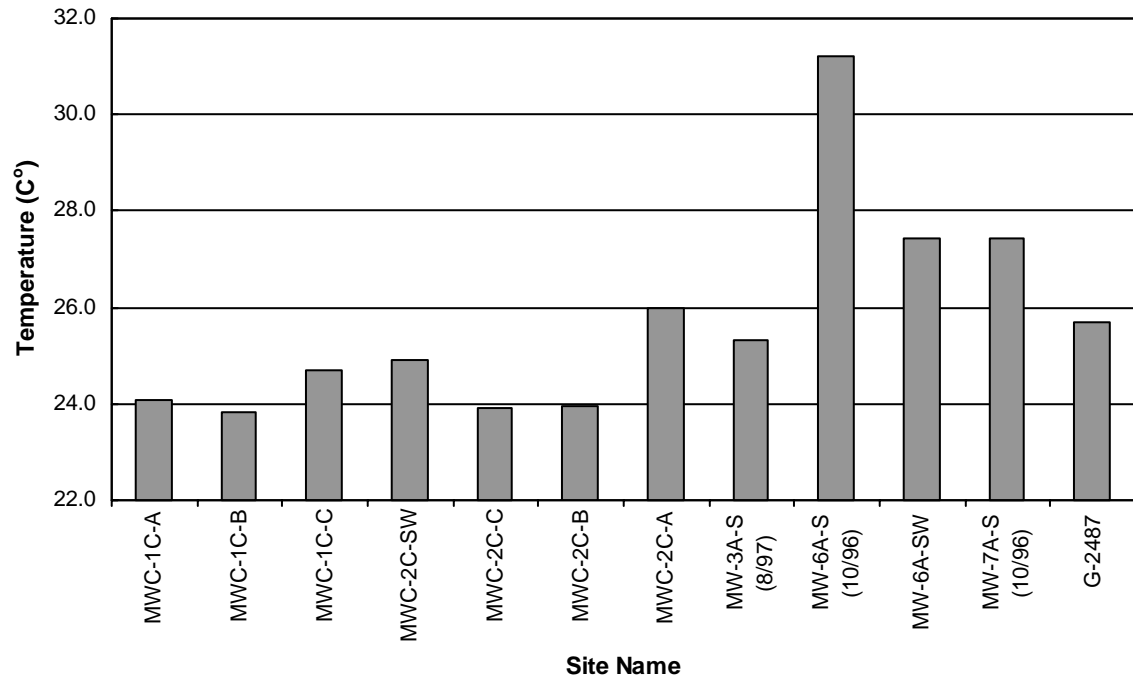


Figure A-2. Water Temperatures in Pond Apple Slough

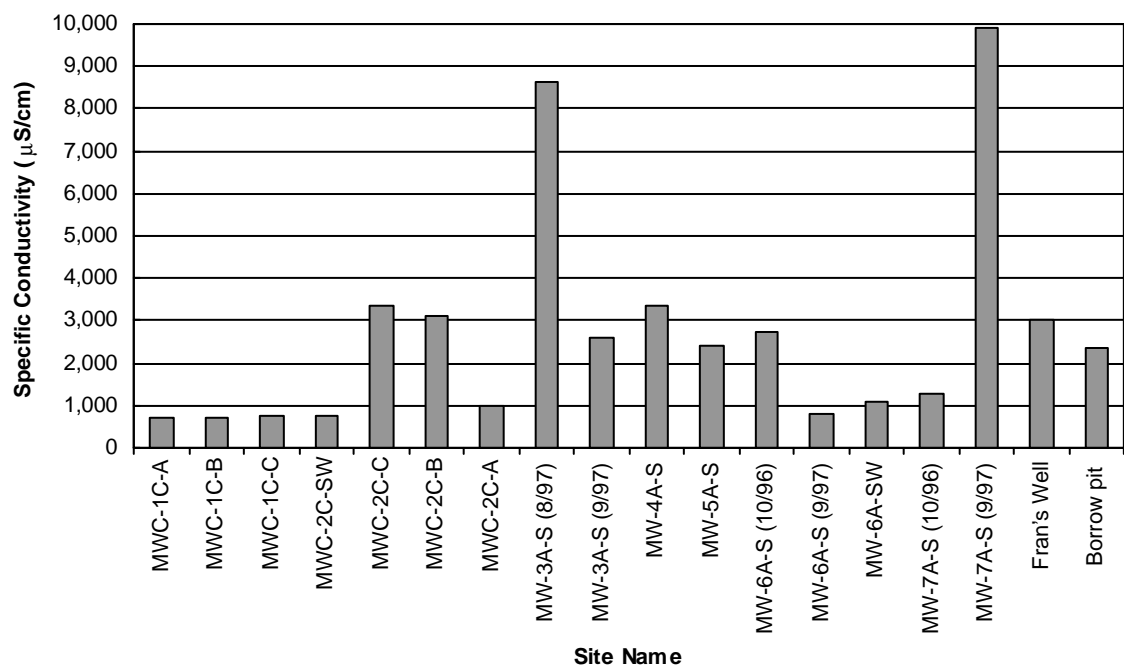


Figure A-3. Specific Conductivity in Pond Apple Slough

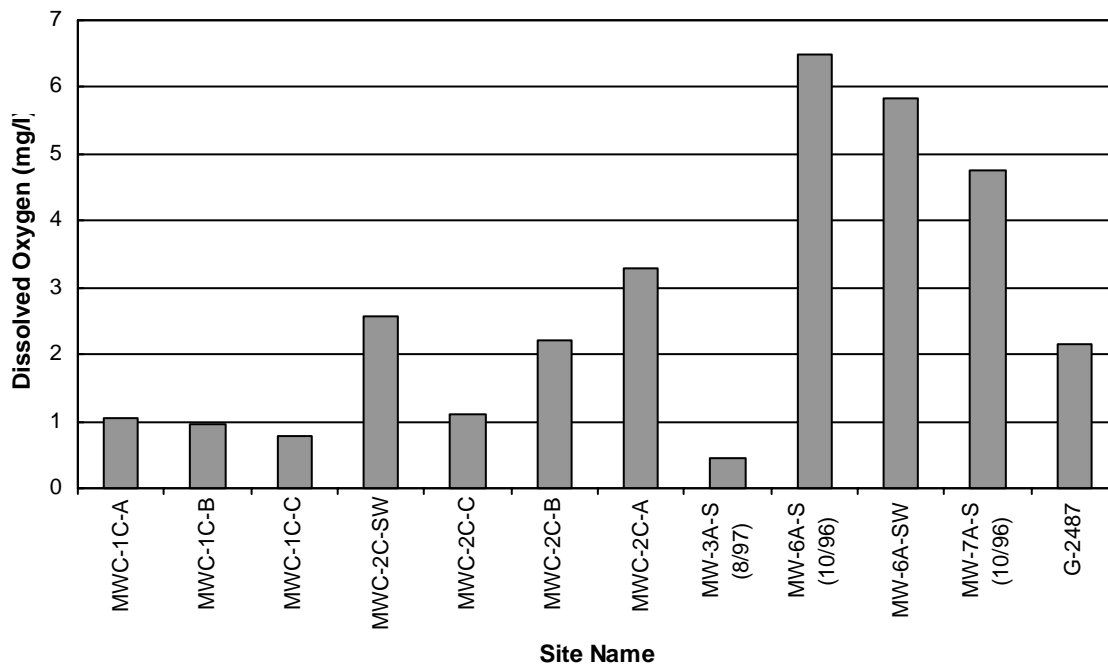


Figure A-4. Dissolved Oxygen in Pond Apple Slough

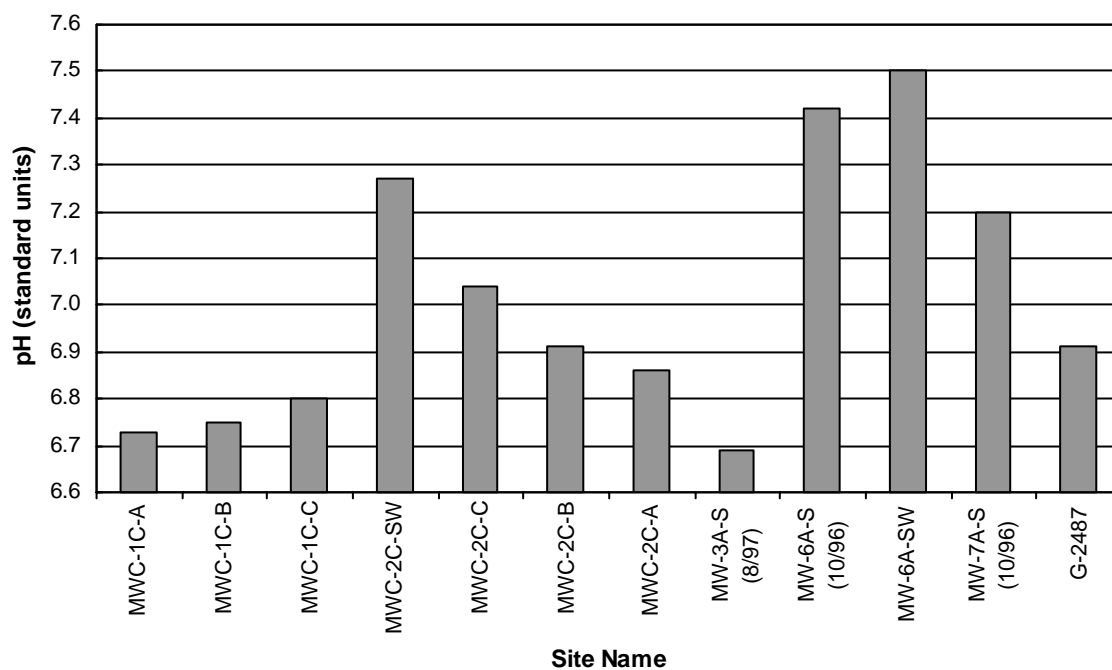


Figure A-5. pH in Pond Apple Slough

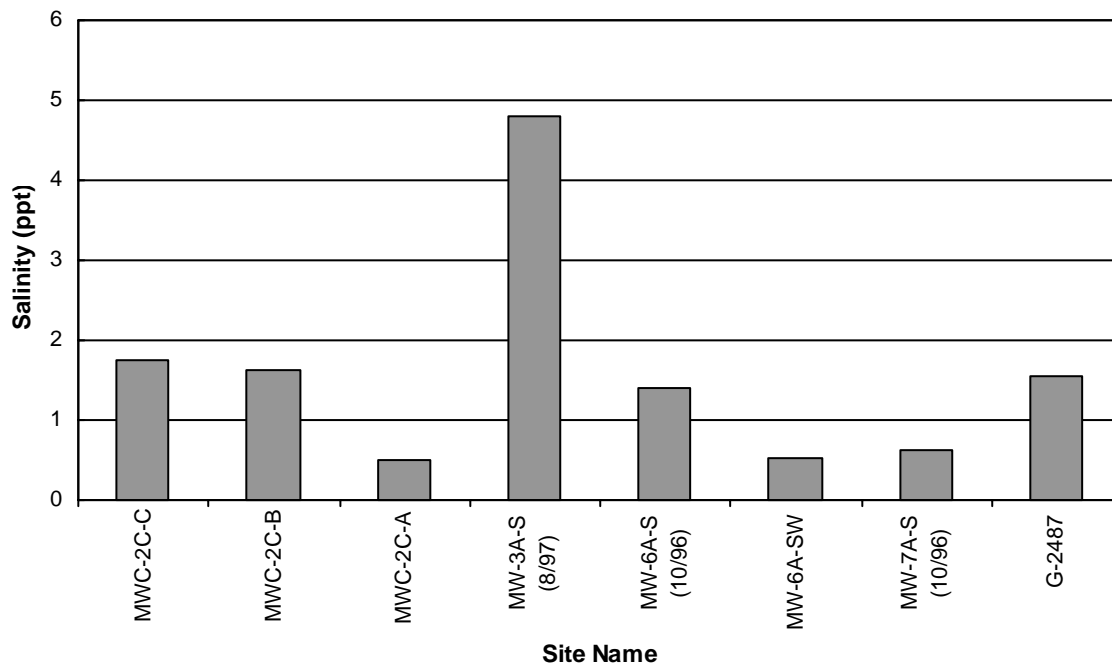


Figure A-6. Salinity in Pond Apple Slough

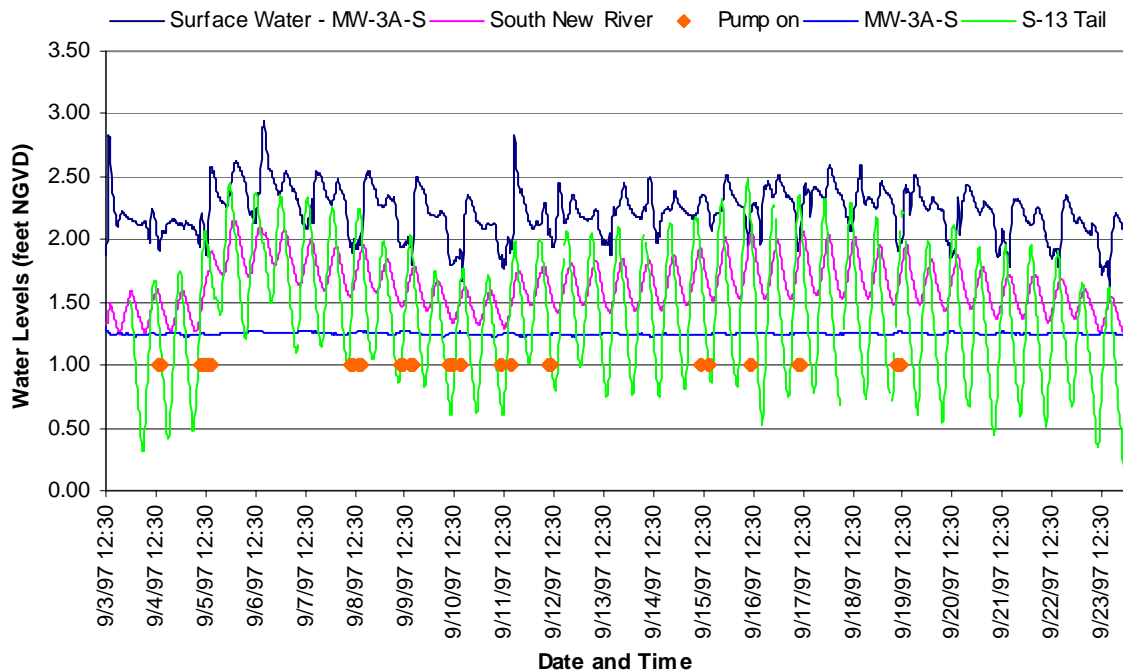


Figure A-7. Groundwater and Surface Water Levels with Pumping Times for MW-3A-S at Pond Apple Slough

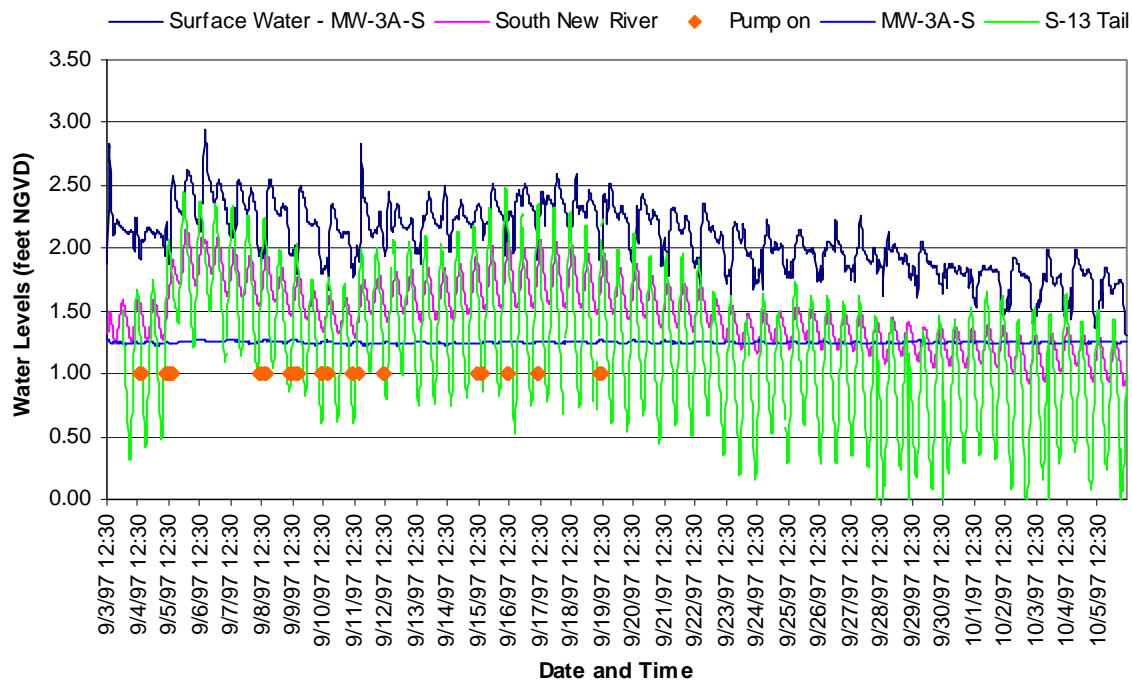


Figure A-8. Groundwater and Surface Water Levels with Rehydration Pump Times for MW-3A-S at Pond Apple Slough

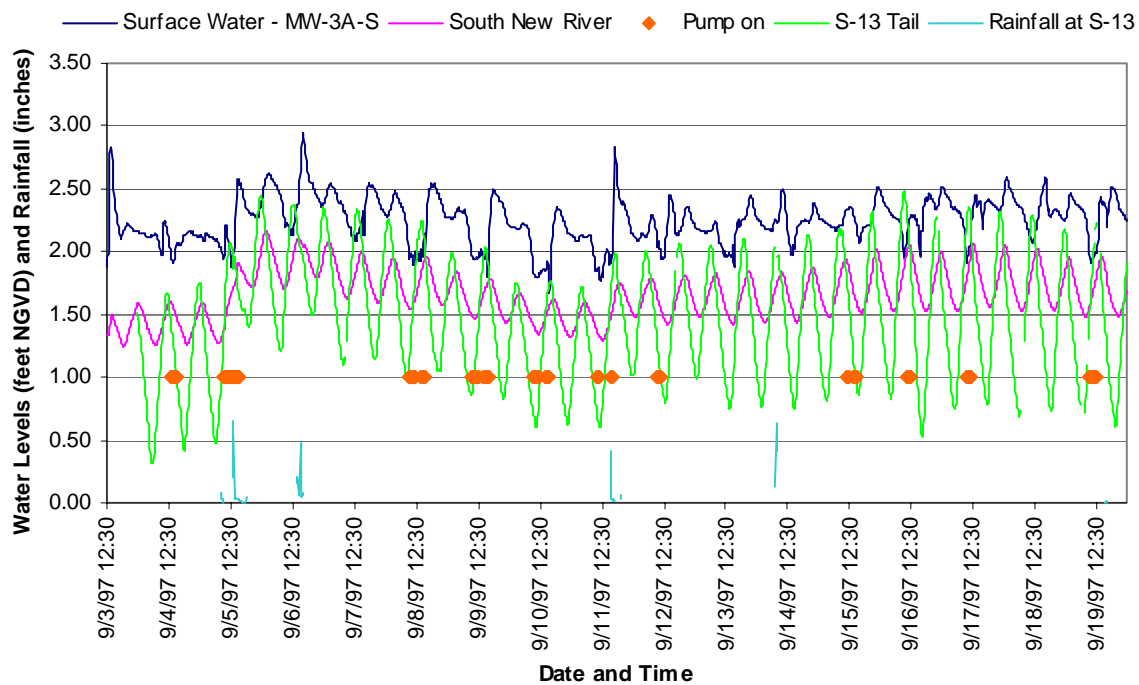


Figure A-9. Surface Water Levels, Rainfall, and Pumping Periods for MW-3A-S at Pond Apple Slough

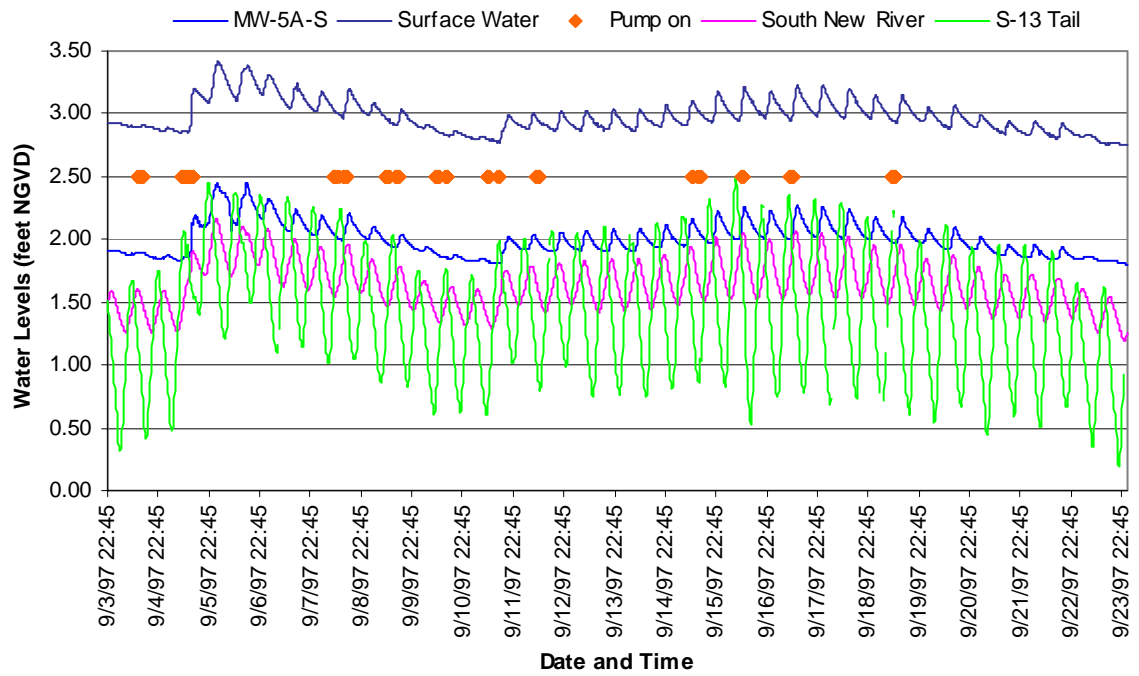


Figure A-10. Groundwater and Surface Water Levels with Pump Times for MW-5A-S at Pond Apple Slough

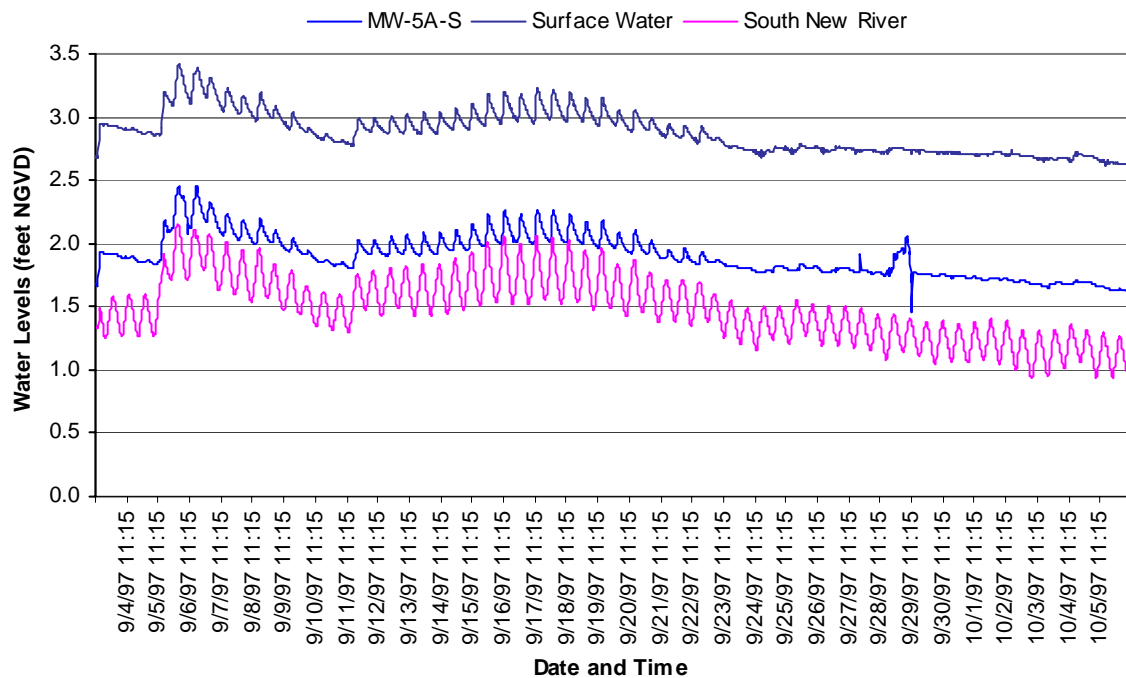


Figure A-11. Groundwater and Surface Water Levels for MW-5A-S at Pond Apple Slough

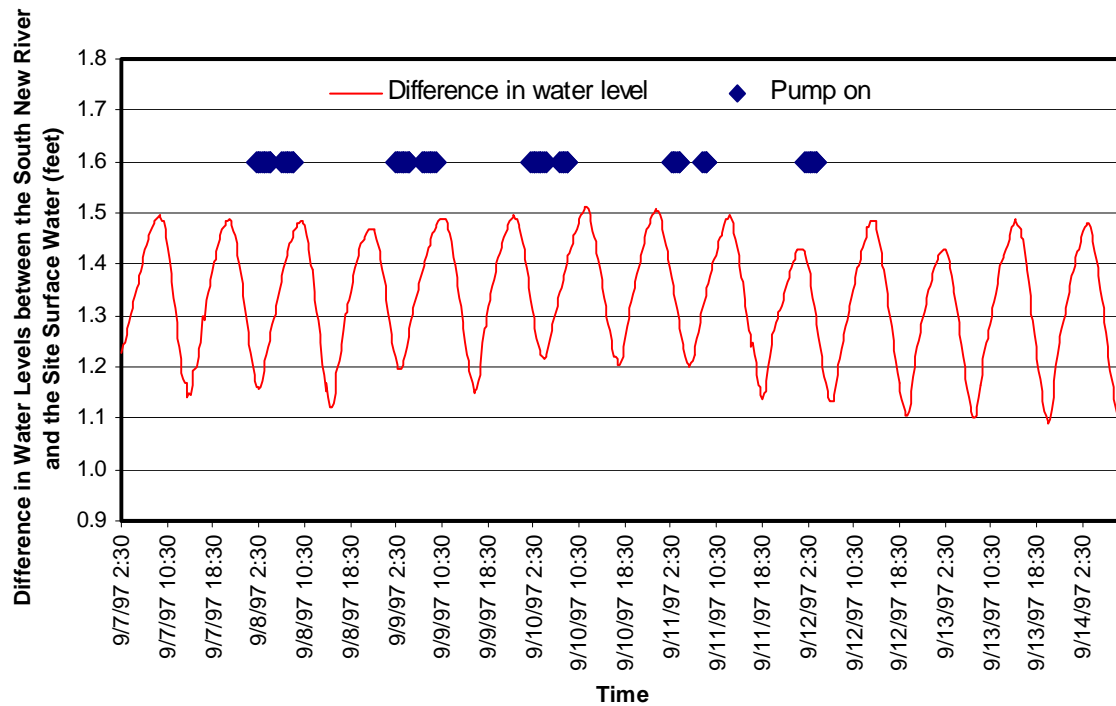


Figure A-12. Effect of Rehydration on Surface Water for MW-5A-S at Pond Apple Slough

Table A-4. Flow at Structure G-54

| Year | Minimum (cfs/day) | Maximum (cfs/day) | Monthly Mean Calculated from Mean cfs per day (dbkey 456) | | | | | | | | | | | |
|------|----------------------|----------------------|---|----------|-------|-------|-----|-------|-------|--------|-----------|---------|----------|----------|
| | | | January | February | March | April | May | June | July | August | September | October | November | December |
| 1940 | 80 | 1,440 | 272 | 466 | 351 | 305 | 147 | 645 | 491 | 819 | 1,073 | 846 | 691 | 541 |
| 1941 | 85 | 1,970 | 729 | 786 | 755 | 1117 | 511 | 513 | 1,535 | 1,322 | 1,089 | 1,164 | 671 | 375 |
| 1942 | 10 | 1,820 | 500 | 382 | 326 | 515 | 373 | 1,456 | 1,384 | 864 | 918 | 641 | 252 | 208 |
| 1943 | 24 | 608 | 108 | 123 | 54 | 42 | 91 | 88 | 297 | 364 | 510 | 435 | 149 | 180 |
| 1944 | 10 | 1,070 | 133 | 32 | 43 | 41 | 104 | 31 | 23 | 137 | 136 | 472 | 282 | 119 |
| 1945 | 3 | 1,390 | 70 | 36 | 12 | 5 | 4 | 4 | 31 | 38 | 427 | 826 | 1,159 | 338 |
| 1946 | 9 | 1,070 | 233 | 46 | 28 | 9 | 52 | 262 | 405 | 553 | 874 | 632 | 588 | 141 |
| 1947 | 2 | 3,280 | 41 | 12 | 481 | 252 | 52 | 808 | 2,048 | 2,248 | 2,125 | 2,151 | 2,714 | 2,199 |
| 1948 | 216 | 2,800 | 1,714 | 1,029 | 470 | 499 | 539 | 312 | 458 | 741 | 1,537 | 2,338 | 2,160 | 1,198 |
| 1949 | 75 | 2,110 | 408 | 238 | 193 | 197 | 238 | 572 | 656 | 756 | 1,144 | 1,391 | 932 | 649 |
| 1950 | 150 | 1,690 | 1,028 | 535 | 329 | 428 | 295 | 396 | 652 | 591 | 543 | 974 | 822 | 411 |
| 1951 | 160 | 1,460 | 250 | 277 | 160 | 262 | 295 | 189 | 623 | 845 | 841 | 1,319 | 1,068 | 517 |
| 1952 | 80 | 1,860 | 264 | 312 | 215 | 173 | 264 | 222 | 480 | 742 | 864 | 1,353 | 1,156 | 674 |
| 1953 | 90 | 1,700 | 570 | 691 | 132 | 168 | 122 | 260 | 641 | 918 | 1,145 | 1,496 | 1,377 | 1,031 |
| 1954 | 184 | 1,660 | 883 | 664 | 689 | 840 | 909 | 1,248 | 1,472 | 1,240 | 1,332 | 1,337 | 770 | 414 |
| 1955 | 75 | 923 | 292 | 199 | 185 | 183 | 169 | 442 | 732 | 624 | 461 | 478 | 125 | 116 |
| 1956 | 20 | 811 | 175 | 78 | 50 | 35 | 63 | 51 | 93 | 37 | 221 | 372 | 83 | 20 |

Table A-4. Flow at Structure G-54 (Continued)

| Year | Minimum (cfs/day) | Maximum (cfs/day) | Monthly Mean Calculated from Mean cfs per day (dbkey 456) | | | | | | | | | | | |
|------|----------------------|----------------------|---|----------|-------|-------|-----|-------|-------|--------|-----------|---------|----------|----------|
| | | | January | February | March | April | May | June | July | August | September | October | November | December |
| 1957 | 20 | 1,460 | 20 | 68 | 139 | 388 | 654 | 520 | 578 | 716 | 1,163 | 1,145 | 401 | 476 |
| 1958 | 176 | 1,600 | 1,164 | 1,073 | 993 | 984 | 931 | 975 | 959 | 977 | 864 | 346 | 243 | 489 |
| 1959 | 36 | 2,040 | 468 | 393 | 404 | 207 | 183 | 872 | 1,421 | 1,305 | 1,303 | 1,110 | 1,047 | 1,213 |
| 1960 | 135 | 1,540 | 743 | 353 | 310 | 318 | 436 | 615 | 530 | 484 | 733 | 1,055 | 1,054 | 911 |
| 1961 | 13 | 952 | 514 | 277 | 193 | 184 | 217 | 309 | 229 | 274 | 252 | 152 | 43 | 16 |
| 1962 | 11 | 495 | 17 | 16 | 14 | 33 | 26 | 157 | 339 | 250 | 338 | 254 | 102 | 52 |
| 1963 | 9 | 907 | 64 | 253 | 87 | 23 | 84 | 138 | 96 | 128 | 348 | 433 | 145 | 65 |
| 1964 | 8 | 1,380 | 241 | 104 | 37 | 29 | 194 | 271 | 145 | 130 | 289 | 581 | 373 | 203 |
| 1965 | 10 | 764 | 75 | 101 | 65 | 27 | 33 | 168 | 212 | 217 | 282 | 283 | 210 | 40 |
| 1966 | 0 | 1,200 | 112 | 126 | 102 | 67 | 15 | 508 | 672 | 873 | 693 | 667 | 329 | 152 |
| 1967 | 15 | 1,610 | 166 | 168 | 44 | 16 | 15 | 615 | 518 | 214 | 141 | 580 | 228 | 75 |
| 1968 | 15 | 1,240 | 29 | 21 | 15 | 15 | 415 | 906 | 1,025 | 560 | 395 | 512 | 277 | 57 |
| 1969 | 15 | 2,160 | 151 | 87 | 116 | 175 | 351 | 348 | 277 | 532 | 295 | 484 | 1,199 | 836 |
| 1970 | 15 | 2,110 | 318 | 223 | 1,209 | 1,262 | 347 | 1,357 | 955 | 289 | 170 | 275 | 197 | 15 |
| 1971 | 15 | 1,170 | 15 | 15 | 15 | 15 | 15 | 39 | 56 | 31 | 27 | 98 | 299 | 117 |
| 1972 | 15 | 1,480 | 47 | 125 | 66 | 57 | 145 | 346 | 221 | 215 | 211 | 79 | 163 | 49 |
| 1973 | 15 | 675 | 19 | 15 | 15 | 15 | 15 | 85 | 179 | 253 | 111 | 82 | 92 | 45 |
| 1974 | 14.4 | 828 | 38 | 14 | 17 | 14 | 14 | 182 | 144 | 190 | 126 | 251 | 69 | 87 |
| 1975 | 15 | 679 | 15 | 15 | 15 | 15 | 15 | 15 | 184 | 231 | 332 | 223 | 103 | 22 |
| 1976 | 15 | 1,240 | 15 | 70 | 31 | 15 | 139 | 210 | 76 | 304 | 192 | 42 | 70 | 28 |
| 1977 | 15 | 909 | 98 | 143 | 15 | 15 | 101 | 197 | 86 | 177 | 436 | 221 | 233 | 201 |
| 1978 | 15 | 960 | 208 | 111 | 53 | 15 | 15 | 137 | 199 | 197 | 196 | 250 | 235 | 89 |
| 1979 | 15 | 828 | 115 | 72 | 41 | 151 | 285 | 73 | 164 | 122 | 224 | 214 | 201 | 145 |
| 1980 | 30 | 778 | 105 | 124 | 127 | 229 | 163 | 146 | 240 | 214 | 322 | 193 | 189 | 124 |
| 1981 | 15 | 1720 | 87 | 175 | 61 | 33 | 44 | 69 | 67 | 288 | 178 | 57 | 72 | 15 |
| 1982 | 15 | 906 | 15 | 18 | 15 | 55 | 98 | 206 | 525 | 208 | 210 | 290 | 307 | 82 |
| 1983 | 15 | 1,040 | 187 | 650 | 728 | 628 | 60 | 302 | 133 | 428 | 286 | 277 | 174 | 132 |
| 1984 | 15 | 1,250 | 417 | 534 | 349 | 93 | 135 | 229 | 196 | 130 | 236 | 86 | 108 | 64 |
| 1985 | 15 | 1,010 | 19 | 15 | 15 | 33 | 24 | 21 | 228 | 97 | 307 | | | |
| 1986 | 49 | 1,230 | | | | | | | | | | 160 | 122 | 715 |
| 1987 | 3 | 1,270 | 259 | 53 | 140 | 61 | 91 | 32 | 77 | 22 | 33 | 124 | 103 | 129 |
| 1988 | 3 | 712 | 34 | 25 | 16 | 15 | 72 | 246 | 168 | 275 | 76 | 12 | 10 | 3 |
| 1989 | 3 | 64 | 3 | 3 | 5 | 3 | 3 | 4 | 7 | 3 | 3 | 3 | 3 | 3 |
| 1990 | 3 | 140 | 3 | 3 | 3 | 3 | 3 | 16 | 24 | 3 | 8 | 17 | 3 | 3 |
| 1991 | 3 | 2,550 | 3 | 4 | 3 | 3 | 17 | 6 | 85 | 105 | 105 | 344 | 39 | 13 |
| 1992 | 3 | 25 | 10 | 6 | 4 | 3 | | | | | | | | |

Table A-5. Flow at Structure G-54S

| Year | Minimum (cfs/day) | Maximum (cfs/day) | Monthly Mean Calculated from Mean cfs per day (dbkey 456) | | | | | | | | | | | |
|-------------|----------------------|----------------------|---|----------|-------|-------|-----|------|------|--------|-----------|---------|----------|----------|
| | | | January | February | March | April | May | June | July | August | September | October | November | December |
| dbkey 15312 | | | | | | | | | | | | | | |
| 1993 | 0 | 915.3 | 122 | 99 | 134 | 85 | 39 | 65 | 154 | 37 | 8 | 235 | 131 | 31 |
| 1994 | 12 | 1,013 | 102 | 32 | 23 | 51 | 12 | 114 | 63 | 176 | 313 | 474 | 1,013 | 878 |
| 1995 | 251 | 787 | 787 | 616 | 577 | 505 | 251 | 379 | 537 | 666 | 718 | 747 | 641 | 623 |
| 1996 | 0 | 612 | 612 | 70 | 34 | 112 | 124 | 360 | 548 | 562 | 357 | 313 | 34 | 0 |
| 1997 | 0 | 429 | 96 | 5 | 0 | 13 | 6 | 227 | 194 | 141 | 389 | 361 | 127 | 429 |
| 1998 | 127 | 823 | 492 | 501 | 644 | 471 | | | | | | | | |
| dbkey 15311 | | | | | | | | | | | | | | |
| 1992 | 0 | 826 | | | | | | 241 | 41 | 138 | 192 | 89 | 217 | 92 |
| 1993 | 0 | 742 | 194 | 91 | 124 | 74 | 26 | 61 | 132 | 22 | 1 | 202 | 117 | 23 |
| 1994 | 0 | 896 | 97 | 26 | 21 | 49 | 15 | | | | | | 799 | 786 |

Table A-6. Flow at Structure S-13 (dbkey 6755)

| Year | Flow (cfs) | January | February | March | April | May | June | July | August | September | October | November | December | Annual |
|------|------------------------|---------|-----------------|---------|-------|-------|---------|-------|--------|-----------|---------|----------|----------|---------|
| 1984 | Minimum | 320.0 | ND ^a | 101.0 | ND | 401.0 | 48.0 | 103.0 | ND | ND | ND | ND | ND | 48.0 |
| | Mean | 1,255.0 | ND | 1,143.4 | ND | 548.8 | 1,208.7 | 219.5 | ND | ND | ND | ND | ND | 902.4 |
| | Maximum | 1,812.0 | ND | 1,841.0 | ND | 599.0 | 1,563.0 | 641.0 | ND | ND | ND | ND | ND | 1,841.0 |
| | Std. Dev. ^b | 575.1 | ND | 714.3 | ND | 98.5 | 455.7 | 136.3 | ND | ND | ND | ND | ND | 619.8 |
| 1985 | Minimum | ND | ND | ND | ND | ND | 132.0 | ND | ND | 101.0 | ND | ND | ND | 101.0 |
| | Mean | ND | ND | ND | ND | ND | 132.0 | ND | ND | 308.5 | ND | ND | ND | 295.9 |
| | Maximum | ND | ND | ND | ND | ND | 132.0 | ND | ND | 581.0 | ND | ND | ND | 581.0 |
| | Std. Dev. | ND | ND | ND | ND | ND | 0.0 | ND | ND | 189.4 | ND | ND | ND | 187.9 |
| 1986 | Minimum | ND | ND | ND | 164.0 | 55.0 | 120.0 | 82.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Mean | ND | ND | ND | 341.2 | 159.5 | 234.7 | 168.2 | 100.8 | 112.9 | 128.8 | 5.2 | 15.7 | 104.7 |
| | Maximum | ND | ND | ND | 595.0 | 269.0 | 365.0 | 336.0 | 419.0 | 211.0 | 587.0 | 156.0 | 185.0 | 595.0 |
| | Std. Dev. | ND | ND | ND | 201.2 | 69.4 | 100.8 | 63.2 | 109.2 | 90.0 | 156.7 | 28.5 | 44.2 | 129.7 |
| 1987 | Minimum | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Mean | 5.4 | 9.9 | 48.3 | 0.0 | 20.0 | 0.0 | 12.8 | 0.0 | 13.8 | 70.8 | 83.4 | 47.8 | 25.6 |
| | Maximum | 168.0 | 163.0 | 399.0 | 0.0 | 203.0 | 0.0 | 192.0 | 0.0 | 142.0 | 501.0 | 268.0 | 446.0 | 501.0 |
| | Std. Dev. | 30.2 | 36.5 | 110.6 | 0.0 | 57.9 | 0.0 | 48.6 | 0.0 | 42.1 | 130.5 | 88.4 | 114.5 | 74.1 |
| 1988 | Minimum | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 56.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Mean | 11.4 | 11.7 | 0.0 | 0.0 | 0.0 | 43.6 | 31.0 | 455.7 | 355.0 | 194.9 | 38.3 | 0.0 | 99.9 |
| | Maximum | 170.0 | 193.0 | 0.0 | 0.0 | 0.0 | 364.0 | 324.0 | 582.0 | 599.0 | 363.0 | 129.0 | 0.0 | 599.0 |
| | Std. Dev. | 40.7 | 44.3 | 0.0 | 0.0 | 0.0 | 114.1 | 79.0 | 129.5 | 209.5 | 133.1 | 56.7 | 0.0 | 177.5 |
| 1989 | Minimum | 0.0 | 0.0 | 0.0 | ND | ND | ND | ND | ND | ND | ND | ND | ND | 0.0 |
| | Mean | 0.0 | 5.0 | 11.5 | ND | ND | ND | ND | ND | ND | ND | ND | ND | 1.4 |
| | Maximum | 0.0 | 65.0 | 200.0 | ND | ND | ND | ND | ND | ND | ND | ND | ND | 200.0 |
| | Std. Dev. | 0.0 | 18.0 | 43.2 | ND | ND | ND | ND | ND | ND | ND | ND | ND | 14.6 |

a. ND = no data available

b. Std. Dev. = standard deviation

Table A-7. Flow at Structure S-13 (dbkey 15131)

| Year | Flow (cfs) | January | February | March | April | May | June | July | August | September | October | November | December | Annual |
|------|------------------------|-----------------|----------|-------|-------|-------|--------|---------|--------|-----------|---------|----------|----------|---------|
| 1990 | Minimum | ND ^a | ND | ND | 0.0 | 0.0 | 0.3 | 60.4 | 36.2 | 0.0 | 22.7 | 0.0 | 0.0 | 0.0 |
| | Mean | ND | ND | ND | 10.1 | 72.2 | 162.3 | 172.1 | 64.4 | 181.4 | 95.3 | 24.2 | 13.7 | 84.5 |
| | Maximum | ND | ND | ND | 98.8 | 420.7 | 406.1 | 1,024.4 | 130.5 | 547.1 | 218.1 | 49.5 | 115.3 | 1,024.4 |
| | Std. Dev. ^b | ND | ND | ND | 30.4 | 121.4 | 102.7 | 186.0 | 23.2 | 180.4 | 46.0 | 13.3 | 24.0 | 112.7 |
| 1991 | Minimum | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 26.0 | 0.0 | 0.9 | -30.2 | 0.0 | 0.0 | -30.2 |
| | Mean | 64.7 | 60.4 | 30.3 | 49.0 | 35.6 | 45.7 | 88.4 | 97.5 | 113.3 | 56.0 | 56.6 | 28.4 | 60.5 |
| | Maximum | 230.5 | 225.3 | 113.6 | 159.5 | 193.9 | 134.4 | 154.0 | 186.5 | 248.1 | 259.5 | 87.6 | 81.7 | 259.5 |
| | Std. Dev. | 72.7 | 69.8 | 40.7 | 49.4 | 55.2 | 48.6 | 35.0 | 52.5 | 45.0 | 72.8 | 19.1 | 16.3 | 56.6 |
| 1992 | Minimum | 20.7 | 4.9 | 0.0 | 1.0 | 0.0 | -0.9 | -0.5 | 0.0 | 55.8 | 0.0 | 0.0 | 0.0 | -0.9 |
| | Mean | 53.5 | 38.6 | 22.3 | 36.6 | 1.0 | 130.5 | 96.3 | 68.3 | 114.6 | 38.5 | 73.3 | 41.2 | 59.5 |
| | Maximum | 154.1 | 126.1 | 83.4 | 105.5 | 17.7 | 345.5 | 209.8 | 169.2 | 185.0 | 104.1 | 174.0 | 134.1 | 345.5 |
| | Std. Dev. | 28.2 | 24.2 | 22.5 | 21.9 | 3.8 | 96.5 | 55.0 | 41.1 | 33.5 | 25.9 | 49.5 | 36.1 | 56.0 |
| 1993 | Minimum | 23.7 | -0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 27.8 | 35.3 | 70.3 | 3.4 | 52.2 | 136.2 | -0.3 |
| | Mean | 90.3 | 47.6 | 99.6 | 38.0 | 16.5 | 87.3 | 143.7 | 94.7 | 110.3 | 115.7 | 152.0 | 166.0 | 97.2 |
| | Maximum | 202.5 | 101.1 | 213.8 | 103.3 | 138.1 | 216.0 | 292.5 | 178.8 | 182.6 | 203.5 | 210.4 | 213.8 | 292.5 |
| | Std. Dev. | 47.0 | 25.8 | 70.5 | 25.0 | 29.7 | 60.6 | 80.4 | 32.5 | 35.7 | 54.0 | 41.0 | 17.4 | 64.0 |
| 1994 | Minimum | 35.2 | 0.0 | 0.0 | 0.0 | 0.0 | 95.3 | 13.7 | 17.9 | 0.0 | 0.0 | -146.0 | -10.7 | -146.0 |
| | Mean | 133.9 | 98.3 | 28.0 | 43.5 | 48.6 | 157.7 | 116.0 | 140.9 | 106.9 | 86.0 | 32.3 | 104.2 | 91.9 |
| | Maximum | 263.5 | 239.2 | 82.1 | 197.5 | 208.6 | 284.9 | 363.8 | 245.0 | 233.3 | 155.3 | 134.3 | 187.8 | 363.8 |
| | Std. Dev. | 76.6 | 61.0 | 22.9 | 67.0 | 41.3 | 58.1 | 86.5 | 56.4 | 69.8 | 45.2 | 52.5 | 50.1 | 72.2 |
| 1995 | Minimum | 45.3 | 15.3 | 55.1 | 0.0 | 0.0 | 0.0 | 0.0 | -1.4 | 0.0 | -0.4 | 40.3 | 86.1 | -1.4 |
| | Mean | 155.0 | 112.2 | 143.3 | 147.9 | 88.1 | 160.3 | 199.6 | 97.5 | 102.4 | 58.1 | 111.0 | 130.9 | 125.6 |
| | Maximum | 220.4 | 205.8 | 198.3 | 217.8 | 215.3 | 349.0 | 279.7 | 230.1 | 233.7 | 177.0 | 189.2 | 186.1 | 349.0 |
| | Std. Dev. | 42.1 | 58.6 | 43.6 | 42.1 | 75.4 | 103.7 | 56.5 | 73.7 | 59.9 | 61.9 | 34.4 | 26.4 | 69.6 |
| 1996 | Minimum | 60.1 | 0.0 | 0.0 | 0.0 | 0.0 | -2.1 | 9.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -2.1 |
| | Mean | 123.2 | 115.1 | 20.8 | 90.9 | 123.8 | 161.6 | 76.5 | 66.3 | 91.1 | 73.6 | 38.8 | 0.0 | 81.5 |
| | Maximum | 175.6 | 172.2 | 103.9 | 160.1 | 363.4 | 364.4 | 138.5 | 244.6 | 199.8 | 184.4 | 153.2 | 0.0 | 364.4 |
| | Std. Dev. | 30.6 | 52.8 | 30.2 | 58.4 | 134.6 | 96.3 | 35.9 | 67.1 | 57.1 | 64.3 | 42.2 | 0.0 | 77.9 |
| 1997 | Minimum | 0.0 | 0.0 | 8.0 | 0.0 | 0.0 | -351.9 | 36.0 | 90.0 | 0.0 | 51.6 | 31.6 | 138.5 | -351.9 |
| | Mean | 13.0 | 72.0 | 76.1 | 96.5 | 58.7 | -34.0 | 121.9 | 167.8 | 171.8 | 121.5 | 112.0 | 252.9 | 102.9 |
| | Maximum | 90.3 | 257.8 | 262.3 | 396.9 | 249.1 | 81.6 | 289.1 | 330.7 | 275.5 | 223.1 | 178.9 | 333.3 | 396.9 |
| | Std. Dev. | 29.3 | 66.7 | 58.7 | 92.5 | 53.5 | 108.3 | 63.5 | 63.2 | 70.6 | 45.3 | 41.1 | 59.5 | 97.3 |
| 1998 | Minimum | 205.6 | 0.0 | 266.7 | 0.0 | ND | 0.0 | 58.1 | 0.0 | 0.0 | 89.0 | 0.0 | 60.5 | 0.0 |
| | Mean | 290.6 | 299.7 | 348.5 | 199.3 | ND | 14.9 | 161.9 | 85.1 | 44.5 | 135.8 | 135.2 | 106.5 | 167.7 |
| | Maximum | 339.9 | 415.2 | 397.9 | 381.1 | ND | 68.6 | 320.5 | 155.2 | 172.7 | 225.0 | 270.7 | 234.6 | 415.2 |
| | Std. Dev. | 37.1 | 123.3 | 32.3 | 140.7 | ND | 23.2 | 76.2 | 40.4 | 59.8 | 38.0 | 72.0 | 45.7 | 123.7 |
| 1999 | Minimum | 28.5 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 22.0 | 0.0 | 0.0 | 0.0 | 49.9 | 261.7 | 0.0 |
| | Mean | 98.1 | 53.7 | 51.6 | 0.0 | 4.8 | 143.1 | 92.6 | 143.4 | 101.0 | 178.6 | 217.4 | 330.1 | 118.4 |
| | Maximum | 219.2 | 146.5 | 144.3 | 0.0 | 83.2 | 336.5 | 231.4 | 342.3 | 225.3 | 709.2 | 289.1 | 368.1 | 709.2 |
| | Std. Dev. | 49.8 | 36.4 | 43.2 | 0.0 | 17.0 | 90.1 | 57.7 | 88.0 | 68.1 | 176.3 | 58.5 | 25.7 | 115.8 |
| 2000 | Minimum | 134.6 | 158.4 | 0.0 | 45.3 | 0.0 | 48.4 | 62.5 | 0.0 | 32.6 | 0.0 | 0.0 | 40.1 | 0.0 |
| | Mean | 256.2 | 213.0 | 213.6 | 212.8 | 67.4 | 138.6 | 138.9 | 94.0 | 113.9 | 101.6 | 43.9 | 85.3 | 139.7 |
| | Maximum | 365.0 | 313.1 | 384.9 | 289.2 | 277.8 | 339.1 | 301.5 | 178.3 | 235.2 | 350.1 | 80.6 | 186.0 | 384.9 |
| | Std. Dev. | 68.5 | 36.0 | 86.2 | 65.8 | 75.5 | 70.2 | 57.0 | 42.7 | 43.5 | 93.8 | 22.6 | 41.7 | 89.8 |

a. ND = no data available

b. Std. Dev. = standard deviation

